SL 235

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Flatwoods Citrus Best Management Practice: Minimizing Direct Deposition of Pesticides into Waterways[1]

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Introduction

Deposition of pesticides on non-fruit or tree surfaces (non-target deposition) is both an economic loss to the grower and a potential environmental problem. Much research has documented factors and the possible magnitude of spray drift in agricultural production systems (Spray Drift Task Force, 1997). Differences in canopy characteristics, wind, relative humidity, planting density, and other factors may all significantly affect spray drift (reviewed by Stover et al., 2003). Smaller droplets are generally more prone to drift, with ground deposits typically being greatest within 50 ft of the sprayer (Fox et al., 1993; Hobson et al., 1993; Johnson, 1995; Salyani and Cromwell, 1992; Walklate, 1992). The percentage of material drifting off-site increases with both wind speed and decreased droplet size.

The potential for surface water contamination in flatwoods citrus production areas is not restricted to long-range drift of spray materials. Most of these groves are situated on poorly-drained soils with shallow hardpans and perched water-tables. These groves are almost always bedded to expedite drainage and provide adequate rooting space for the trees. Groves are designed so that rainfall drains rapidly from the beds through a series of water furrows connected to drainage ditches and larger canals (Figure 1).

Figure 1. Typical layout of flatwoods citrus production areas. Note proximity of drainage canal to end of tree rows. Credits: PCW

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These ditches and canals represent a direct linkage to streams, rivers, lakes and estuaries, making minimization of pesticide losses from production areas especially important. These ditches and canals also serve as aquatic habitat for a variety of invertebrate, fish, bird, and mammal species. Direct deposition of applied pesticides to the water surfaces of adjacent ditches and canals may present significant ecological risks, depending on the applied pesticide.

Since lateral drainage ditches and canals are often located perpendicular to tree rows, shutting off sprayer nozzles when approaching the end of tree rows should reduce drift of pesticides into these non-target surface water bodies. In practice, sprayer operators may not always turn sprayers off at the end of tree rows because of preoccupation with several aspects (scanning for oncoming traffic and obstacles, avoiding water furrow pipes, etc.) of safely exiting the row and making an 180^{o} turn into the next row, especially if they are driving in a water furrow.

This document summarizes the results from a study evaluating the effectiveness of turning sprayer nozzles off at row ends as a proposed best management practice (Boman et al., 2000) for preventing non-target deposition of pesticides in surface water connections such as irrigation and drainage ditches. It also estimates direct deposition on ground surfaces that translate into wasted product, as well as another potential source of surface water contamination through surface water runoff. More detailed information regarding this study can be found in Wilson et al. (2004).

Summary of Methods

Specific row-end spraying strategies evaluated

1. Leaving both banks of nozzles on while turning;
2. Turning the outside-facing nozzles off (leaving tree-facing nozzles on);
3. Turning both banks of nozzles off at the tree trunk;
4. Turning all nozzles off at the end of the foliage of the last tree within the row.

Site Description

This study was conducted within a commercial, double-bedded citrus grove located in St. Lucie County, FL. This grove was planted with white Marsh grapefruit (on sour orange rootstock) trees that were greater than 20 years old and were approximately 18 ft tall. Distance between tree rows averaged 28.5 ft both across bed tops and furrows. These studies were conducted along a drainage ditch that separated two blocks of citrus within the grove. This ditch was located approximately 23 ft from the edge of the last tree within each row. The ditch was 25 ft wide. The vertical distance from the ground surface down to the surface of the water within the ditch was approximately 5.4 ft.

Copper Applications

Copper hydroxide formulated product was used as a model pesticide because of its low human toxicity and its stable disposition, having few special handling and storage requirements for accurate analysis. Copper is routinely used in fungicidal applications to commercial citrus in the region. Copper applications were made in June and again in July 2001. A summary of application materials is shown in Table 1.

Table 1. Summary of copper application materials.

Sprayer	PTO driven air-blast
Nozzle #	20 (10 on each side)
Nozzle placement	5-No. 5 TeeJet discs on bottom 5-No. 6 TeeJet discs on top TeeJet 4S cores
Application rate	115 gal./acre
Copper formulation	Copper hydroxide (77% a.i./50% metallic)
Mixing rate	12 Lbs. product/500 gal. water

Evaluations were made with the tractor spraying only bed-tops. Within this type of double-bedded grove, pesticide applications to the furrow side of the trees were made after the sprayer was adjusted for tree elevation differences. Applications were started before 8:00 AM and lasted until approximately noon during both dates of the study.

Estimation of Non-target Deposition

The area evaluated was divided into three distinct zones: 1) ground surfaces adjacent to the sprayer, 2) water surface within lateral canal, and 3) ground surfaces across the canal from the sprayer. Deposition directly on the ground or water surfaces was estimated by multiplying the average amount of copper on each set of targets (i.e. ground-sprayer side, water surface, ground-opposite side) by the grove surface area encompassed by each set of targets. The total ground surface areas encompassed 3,645 ft^2, while the surface area of the water within the ditch was 4,050 ft^2.

Deposition Results

Deposition during the June application was generally greater than that found in July. This was not unexpected since a variety of factors, including wind speed and direction, temperature, and humidity can influence droplet size and non-target deposition. These factors were reviewed by Stover et al. (2003). A summary of the deposition results obtained follows.

Adjacent to Sprayer

Copper deposition adjacent to the sprayer was more similar among the four treatments in June than in July (Figure 2). On both application dates, turning the outside nozzles off at the foliage edge through the turn resulted in less deposition than when leaving both sets of nozzles on. Turning both sets of nozzles off at the tree trunk, and turning off only the outside-facing nozzles also reduced deposition on the ground surface adjacent to the sprayer. Deposition ranged from 142 to 369 mg (0.005 to 0.013 oz) in June. In contrast, deposition on the ground surface during the July application was significantly higher when both nozzles were left on through the turn, relative to all of the other treatments. In this case, leaving all nozzles on through the turn resulted in 142 mg (0.005 oz), compared to 28 mg (0.001 oz) for the other treatments.

Within Lateral Canal

Similar deposition patterns were apparent for both application dates (Figure 2). However, deposition was generally greater during the June application. In both cases, deposition was significantly reduced when the outward-facing or both banks of nozzles were turned off, regardless of timing. During the June application, an estimated 6,747 mg (0.238 oz) was deposited directly on the water surface when all nozzles were left on through the turn, as compared to 2,013 to 2,892 mg (0.071 to 0.102 oz) with the other treatments. During the July study, 2,637 mg (0.093 oz) were deposited on the water surface when all nozzles were left on as compared to 340 to 879 mg (0.012 to 0.031 oz) with the other treatments. Turning all or the outside-facing nozzles off through turns reduced direct deposition on the water surface by 57-70% during the June application and 67-87% during the July application.

Opposite Side of Lateral Canal

Row-end spraying strategies did not influence copper deposition on ground surfaces on the opposite side of the drainage canal from the sprayer. Again, deposition during the June application was higher than in the July application. Deposition on the ground surface ranged from 72 to 130 mg (0.003 to 0.005 oz) during the June application and 16 to 24 mg (0.0006 to 0.0008 oz) during the July application.

Discussion

The row-end spraying techniques compared in this study are representative of those commonly used for citrus production in flatwoods areas. Continuing to spray from both sides of the sprayer while rounding the row ends, which resulted in highest deposition, has never been a recommended practice but is occasionally observed. These studies illustrate the importance of shutting off the outer nozzles to reduce off-target deposition on water and ground surfaces, but do not indicate a significant difference in the off-target deposition between any of the remaining techniques.

The difference in mean deposition measured on each of the two study dates is quite remarkable. Each of the study dates had very similar wind speed and relative humidity. The difference in deposition may have resulted from the very different wind direction on the two study dates. The wind direction during the

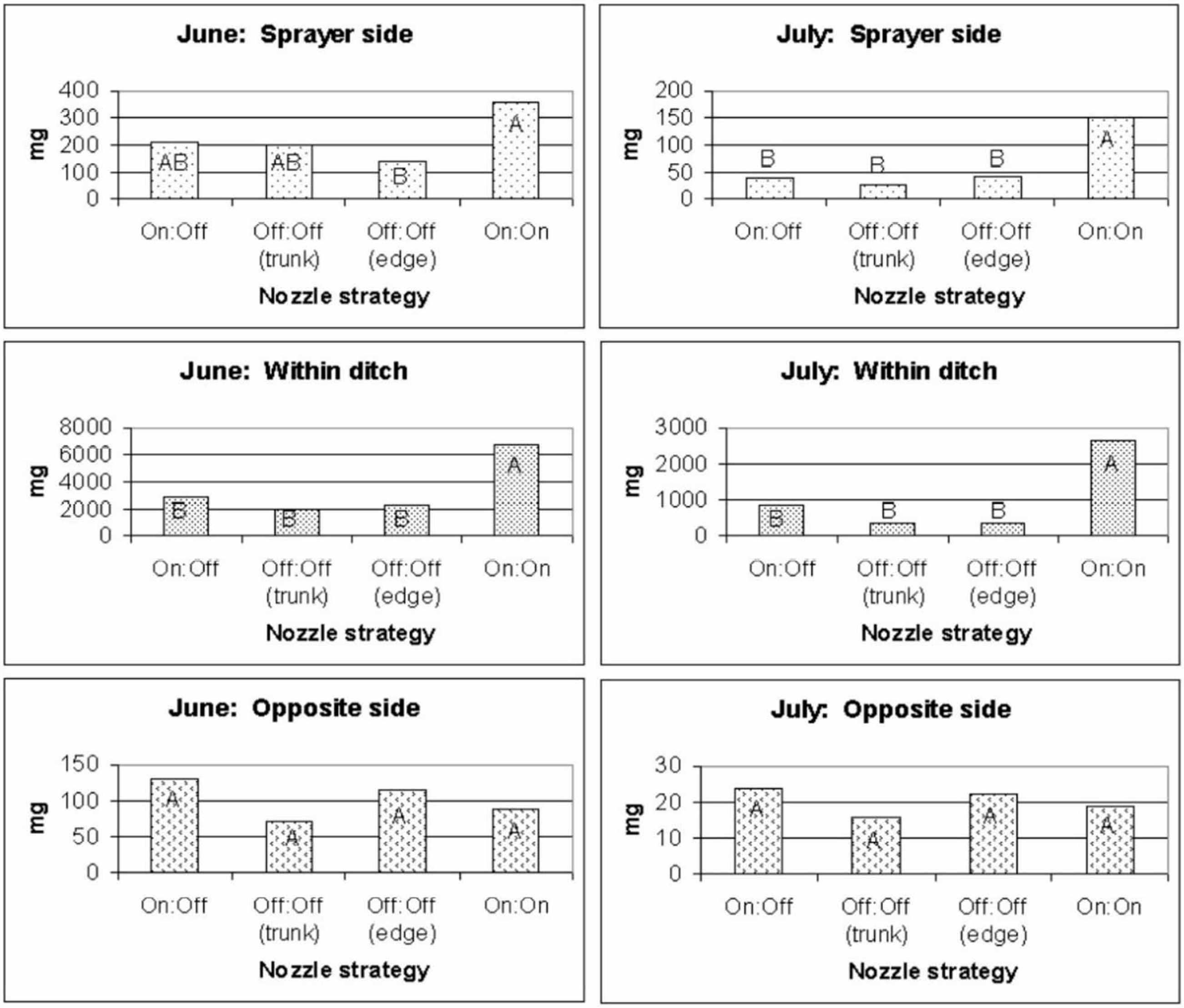

Figure 2. Copper deposition on ground and water surfaces relative to nozzle operation through the turn at the end of the tree row. On:On = leaving all nozzles on through the turn, On:Off = turning outward facing nozzles only off, and Off:Off = turning all nozzles off. The same letter indicates statistical similarity (ANOVA *P*=0.05). Credits: Wilson et al. (2004)

June study date was primarily from the northeast, resulting in a mean wind speed of 3.4 mph in a southerly direction, which resulted in a greater wind movement between the North-South oriented rows. Even though wind speed was well within that considered suitable for foliar applications (Stover et al., 2003), it may have significantly influenced off-target deposition.

The recently published Best Management Practices manual for Indian River citrus (Boman et al., 2000) specifically recommends turning the sprayer nozzles off at the trunk of the last tree within rows, followed by making a final pass around the outside perimeter with only the tree-side nozzles operating (wrapping). While our data indicate that this approach reduces off-target deposition relative to continued spraying from outside nozzles, it does not address deposition resulting from the final wrapping application. The additional BMP-specified spray applied during the final wrapping process requires more spray material, worker time, and almost certainly increases non-target deposition on both bed-tops and water furrows. In contrast, leaving the inner nozzles on while rounding the tree row is likely to result in much higher applications of the pesticides to the row end relative to the remaining trees in the row, suggesting inefficient use of spray material (Indian River growers, personal communication).

Therefore, these data and the accompanying discussion suggest that continuing to spray just to the end of the foliage on the row ends without the added step of wrapping the perimeter should be considered as a new improved BMP to reduce non-target deposition of spray-applied pesticides. Growers should confirm adequate control at the row ends through scouting programs and make application adjustments if needed.

Summary

Considering that most groves in flatwoods citrus production areas have similar drainage systems, the possible environmental benefits of turning outside-facing nozzles off during turns can be significant. In addition to demonstrating the reduction in direct deposition of a pesticide on water and ground surfaces, these studies also demonstrated the inherent variability that can be expected in non-target deposition, even when applications are made at the same rates and under relatively similar climatic conditions.

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